Monitoring for quality and safety in a pharmaceutical lab

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Pharmaceutical research and development requires a well-regulated environment. SmithKline Beecham Pharmaceuticals operates a comprehensive system that maintains the environment of its research and development laboratories in Upper Providence Township, Pennsylvania. The 92,000 square metre (1 million square foot) complex has 65,000 square metres (700,000 square feet) of laboratory space. Within it are laboratory areas designated as Good Laboratory Practices and Good Manufacturing Practices. The laboratories require stringent operating conditions, and reliable quality and safety systems. Air pressure, temperature and humidity must be accurately maintained and documented for regulatory agency reports. The equipment that maintains the environment in those areas is critical to plant operation. That equipment includes air handling fans, chillers, cooling tower fans and boiler feed pumps. The exhaust fans that vent potentially hazardous or toxic substances are extremely critical.

Figure 1
Specially designed brackets for bearing-mounted accelerometers.

SmithKline Beecham's Facilities Engineering Department, working with area Laboratory Managers, identified 150 pieces of equipment that were critical to scientific research and employee safety. It was decided that those machines required a monitoring system that would provide accurate and reliable information for monitoring and evaluating equipment condition to:

- Reduce machinery downtime, avoid catastrophic failures and any interruption to research.
- Reduce maintenance costs, in both labor and materials.
- Extend equipment life.

The Facilities Engineering Department's investigation showed that a permanent vibration monitoring system was essential for detecting machine problems at an early stage of development. It also showed that a system which trended vibration and had diagnostic tools could greatly reduce maintenance costs. SmithKline Beecham decided to install permanent vibration monitoring equipment on all 150 critical machines, and to link the monitors to a computerized trending and diagnostic system.

SmithKline Beecham chose a Bently Nevada permanent monitoring system for both continuous and periodic monitoring. The continuous monitors protect machines from damage. The periodic monitoring system trends machine vibration and displays vibration in diagnostic plots. In the three years since the system was installed, there have been a significant number of equipment problems discovered. Without a continuous monitoring system these problems would have become much more severe and expensive to correct.

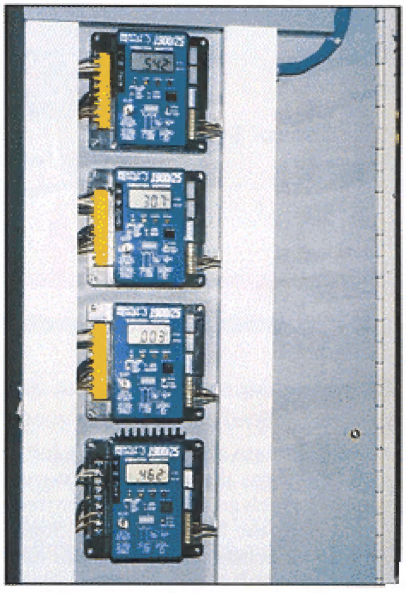


Figure 2
Bently Nevada 1900/25 Monitors mounted in mechanical equipment room.

Installed in three phases

The project team decided to implement its monitoring system in three phases. In phase one, vibration transducers and continuous monitoring systems were installed on each critical machine. A Bently Nevada 89129 Accelerometer was installed (on each machine), in a location that provides the best "overall condition" measurement. The 89129 Accelerometer has a micro-machined silicon sensor that gives it the mechanical integrity of an accelerometer, but at a cost comparable to a velocity transducer. Specially-designed brackets were used to simplify accelerometer installation (Figure 1). Each accelerometer was connected to a Bently Nevada 1900/25 Monitor. The 1900/25 Vibration Monitors are single-channel, cost-effective continuous monitoring systems for essential and general-purpose machinery. The 1900/25 Monitors were mounted in groups in several mechanical equipment rooms (Figure 2). The Alert relays on each group of monitors were connected to a strobe light (Figure 3) in each mechanical equipment room. The strobe light warns technicians when an alert condition occurs. Each monitor's Danger relay is connected to a machine control system for automatic shutdown. If vibration increases 30% above normal, the 1900/25 Monitor shuts down the machine, and the Building Automation System (BAS) automatically starts up a redundant unit.

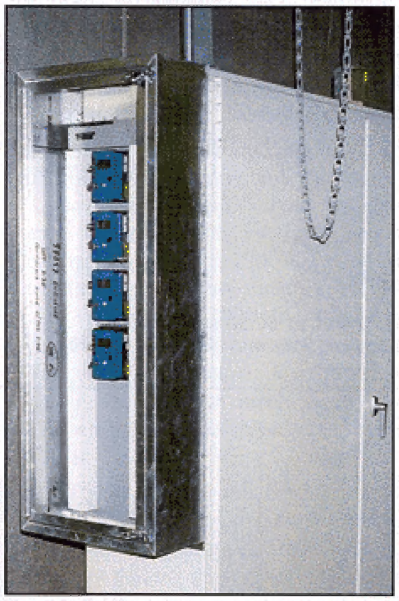


Figure 3
Typical 1900/25 Monitor installation. Note strobe light on top of cabinet.

The 1900/25 Vibration Monitors that SmithKline Beecham selected have a built-in Trendmaster® 2000 interface, which made it easy to implement phase two of the machinery protection system plan. In the second phase, SmithKline Beecham installed Bently Nevada's Trendmaster 2000 for Windows System, to automate data collection and provide online diagnostics. Trendmaster 2000 for Windows is a computer-based, online system that automatically samples, processes and trends vibration data. It is a periodic monitoring system; each point is sampled at regular, short intervals, rather than continuously. Periodic monitoring allows a single signal cable to carry the data from up to 255 points. This design vastly reduces wiring costs. Compared with systems that require an individual wire for each transducer, Trendmaster 2000 for Windows is significantly less expensive to install and expand. In fact, SmithKline Beecham used the existing phone cable system to connect the 1900/25 Monitors to the Host Trendmaster 2000 Computer, which is located in the Central Utilities Plant.

Trendmaster 2000 for Windows can be easily integrated into computer net-

Machine Type	No. of incidents	Types of problems
Exhaust Fan	53	Loose or worn drive belts; loose hardware; structural cracks; bad or worn bearings; unbalance; misalignment; incorrect, misaligned or failed sheaves; untrue bearing mounting surfaces (soft foot).
Air Handling Unit	24	Bad, loose, worn or incorrect belts; loose or missing bolts; bad or worn bearings; unbalance; motor soft foot; bearings with excessive play.
Return Fan	3	Worn belts; misalignment; unbalance; lack of lubrication.
Cooling Tower Fan	3	Bad bearings; misalignment; loose hardware.
Pump	2	Worn coupling; misalignment.
Scrubber	1	Poor belts and alignment.
Chiller	1	Coupling misalignment; damaged coupling element.

Figure 4
Summary of saves from 1900 Monitor and Trendmaster® 2000 for Windows System.

works and Distributed Control Systems. This was an important reason the system was chosen. In the third phase of the installation, Facilities Engineering plans that the Trendmaster 2000 will be integrated into the plant's existing Building Automation System.

Machinery saves

SmithKline Beecham's Upper Providence Township, Pennsylvania facility has not had a critical equipment failure since the vibration monitoring program was implemented. Some machine saves have resulted in substantial savings. The detection of a defective coupling element on a chiller unit which, if allowed to run in that condition, could have cost approximately $30,000 in materials and labor to repair. On the same day it was installed, The Trendmaster 2000 for Windows system detected a defective bearing in a cooling tower gear reducer, potentially saving $10,000 in material and labor costs.

All equipment vibration problems are analyzed for root cause using the Trendmaster 2000 data. So far, over 100 equipment problems have been documented. The incidents are summarized in Figure 4. These are a few examples.

Vibration increased steadily on an Air Handler Unit, until an Alert alarm occurred. The critical machine couldn't be shut down immediately, so the condition was monitored closely until early November when a scheduled outage was planned. Although the vibration levels continued to rise (Figure 5), the unit was safely operated until a planned shut-

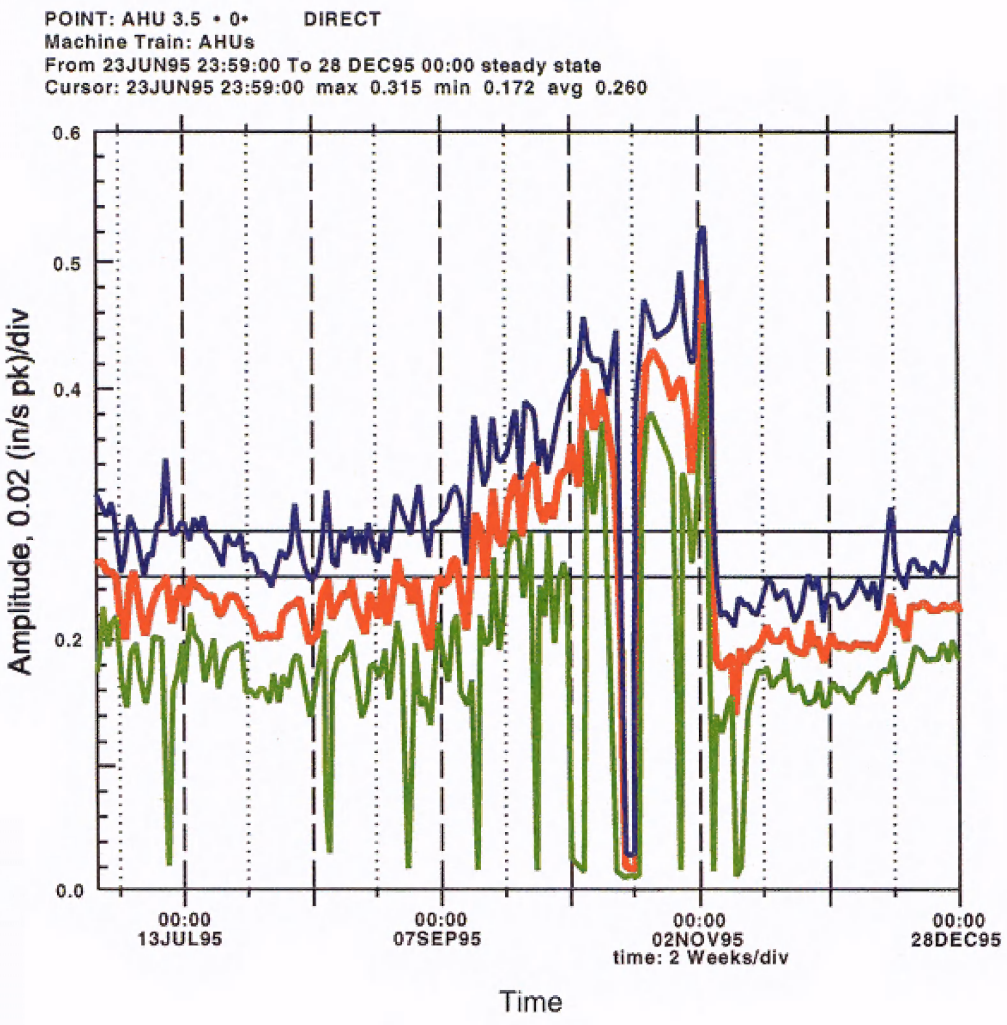


Figure 5
Plot showing minimum, average and maximum vibration values of the Air Handler Unit. Note that the sudden decrease in amplitude after 2 November shows the effect of the balancing.

down was scheduled and the fan was examined. The diagnostic plots indicated an unbalance condition. Using this data, the machine was balanced. Afterward, vibration returned to an acceptable level.

In another instance, trend data showed that a bearing on an exhaust fan had high vibration. Over time, the prime spike reading had risen by 3.8 mm/s pk (0.15 in/s pk). Prime spike is a frequency range encompassing bearing frequencies generated by rolling elements traversing inner or outer race flaws. Diagnostic plots confirmed a 2.3 mm/s pk (0.09 in/s pk) amplitude spike at 22 times running speed. Further investigation showed that the fan's drive side bearing had excessive movement. The bearing was replaced before further damage could occur.

Another case is when an air handling unit went into an Alert alarm on the Trendmaster 2000 system. While reviewing trend data, a sharp increase in the prime spike was noted. BAS information indicated a recent fluctuation in the air handling system's static pressure. Equipment history obtained from the Computerized Maintenance Management System (CMMS) indicated a past problem with the vortex damper. Technicians discovered and repaired a broken actuator damper spring. The 1900/25 Monitor was sensitive enough to detect a change in the machine's condition, due to the system dynamic effect on the piece of equipment. Through the process of elimination, the problem was located and corrected immediately.

Another save began with an Alert alarm on a 1900/25 Monitor that processed vibration information from a exhaust fan motor. The motor sheave had worked its way to the end of the motor shaft, causing severe misalignment of the V-belts. The problem was immediately corrected and unplanned downtime was avoided.

The 1900/25 Monitor alone has detected several problems. An air handling unit went into a Danger alarm. Upon investigation, it was found that the unit's shaft and its drive side bearing had extreme fretting corrosion. The 1900/25 Monitor's early warning saved this air handling unit from catastrophic failure.

Other benefits

Facility technicians also use the Trendmaster 2000 for Windows System to check the quality of their work. After technicians complete scheduled preventive maintenance and the equipment is returned to service, the Trendmaster 2000 for Windows diagnostic plots are used as a post PM inspection. Technicians use it to check conditions, such as alignment and drive belt tension, immediately after the preventive maintenance procedures.

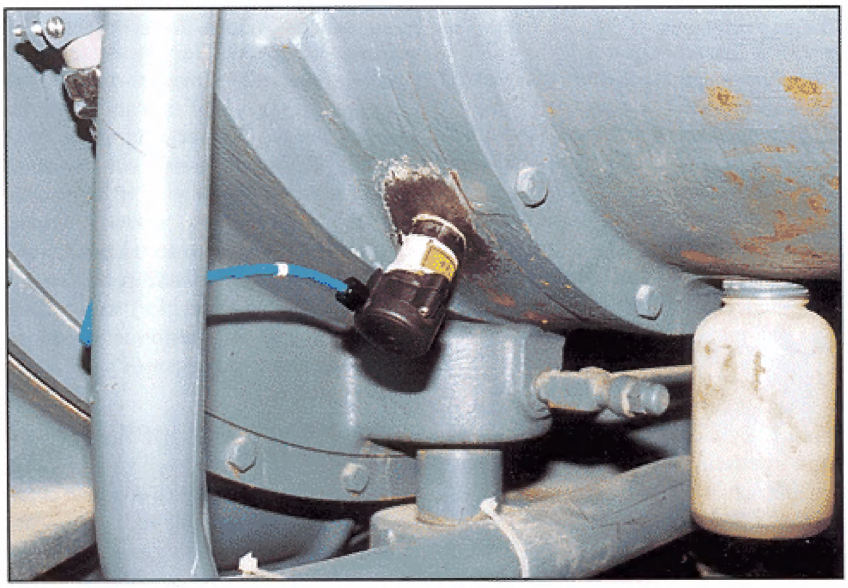
According to Paul Fedyna, Maintenance Engineer with Facilities Engineering, "Trendmaster 2000 has helped us to plan and schedule maintenance. We use Trendmaster 2000 for Windows' Alert levels as an 'early warning system.' When a unit reaches an Alert level, we closely monitor that machine until we can schedule a convenient time to service it.

"The system has also helped improve our machinery maintenance procedures. It has helped educate machinery technicians by making them aware of the critical nature of balance, alignment, bearing/machine mounting surfaces, sheave eccentricity, resonance and looseness and their effect on these small machines. Any small physical change can have a dramatic effect on the vibration signature which can be readily seen on the Trendmaster 2000 trend and spectrum plots. After any work is completed on the unit, the technicians check the Trendmaster 2000 plots and displays to ensure that their work has caused no ill-effects on the equipment."

The future

The Facilities Engineering Department is very pleased by the reduced maintenance costs due to the 1900/25 Monitor and Trendmaster 2000 for Windows System. They are currently investigating whether other machines can be added to the Trendmaster 2000 System. A current project is to add six emergency diesel generators to the system using an accelerometer Transducer Interface Module and a 1900/25 Monitor for emergency shutdown capabilities. In addition a Keyphasor® transducer (proximity probe) will be used to provide phase information.

The next phase of our project is to interface the Trendmaster 2000 for Windows System into the facility's Building Automation System. Plans call for a system that will automatically generate work orders, sending the technicians to the machine, based on the Trendmaster 2000 alarms. ■



Epoxy-mounted accelerometer on a centrifugal chiller.